



Inventory & Monitoring Program

Pacific Island Network

Monitoring Plan

Supporting Documents: Hawaii Volcanoes National Park Resource Overview

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Pacific Island Network (PACN)

Territory of Guam

War in the Pacific National Historical Park (WAPA)

Commonwealth of the Northern Mariana Islands

American Memorial Park, Saipan (AMME)

Territory of American Samoa

National Park of American Samoa (NPSA)

State of Hawaii

USS Arizona Memorial, Oahu (USAR)

Kalaupapa National Historical Park, Molokai (KALA)

Haleakala National Park, Maui (HALE)

Ala Kahakai National Historic Trail, Hawaii (ALKA)

Puukohola Heiau National Historic Site, Hawaii (PUHE)

Kaloko-Honokohau National Historical Park, Hawaii (KAHO)

Puuhonua o Honaunau National Historical Park, Hawaii (PUHO)

Hawaii Volcanoes National Park, Hawaii (HAVO)

<http://science.nature.nps.gov/im/units/pacn/monitoring/plan/>

EXECUTIVE SUMMARY & INTRODUCTION

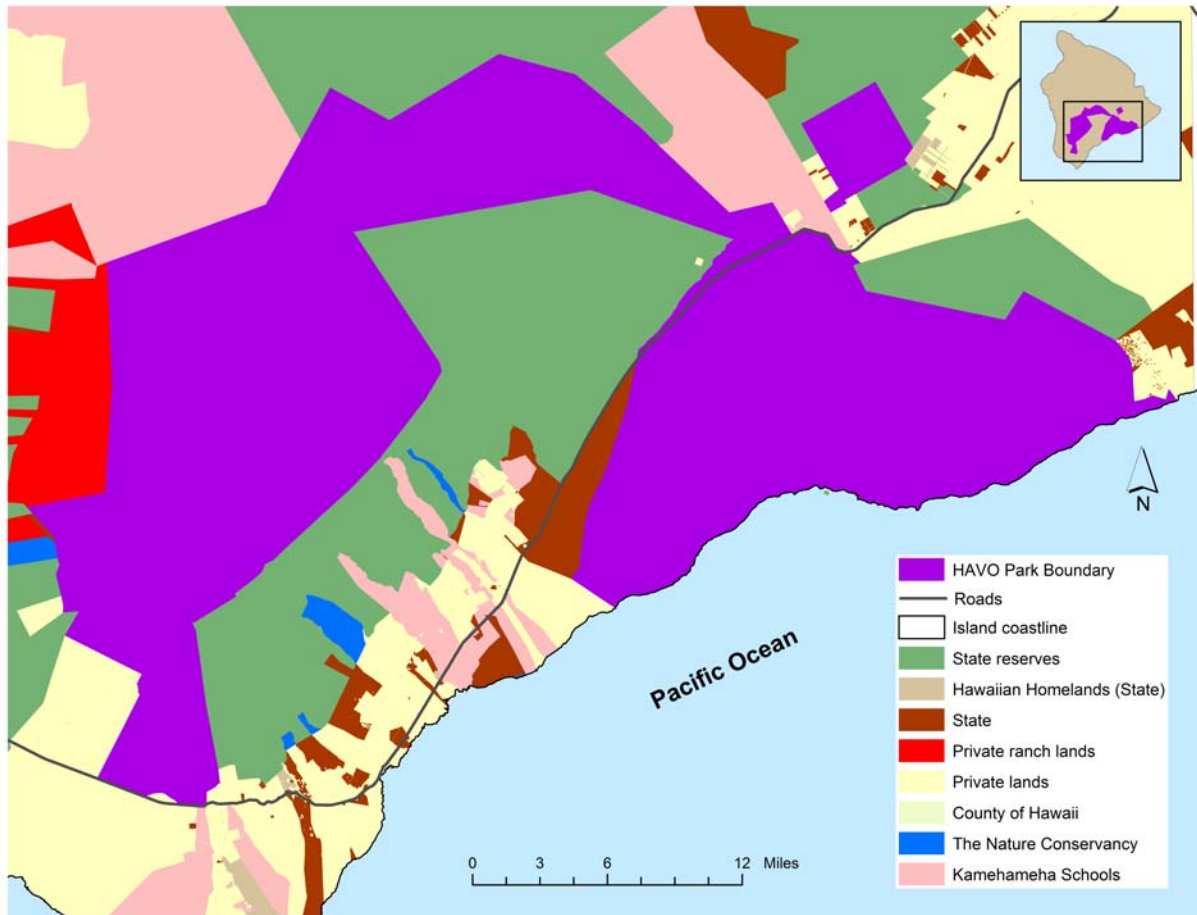
Enabling legislation

The enabling legislation for Hawaii Volcanoes National Park, (16 USC. Sec. 396) (Pub Law 95-635, 16 U.S.C. Sec. 1132), established the Park and states that Hawaii Volcanoes National Park “*shall be perpetually dedicated and set apart as a public park or pleasuring ground for the benefit and enjoyment of the people of the United States...* ” Park enabling legislation also provides for the “*preservation from injury of all timber, birds, mineral deposits, and natural curiosities or wonders within said park, and their retention in their natural conditions as nearly as possible.*”

To find enabling legislation documents on-line follow the “Policy & Legislation” link from the Pacific Island Network website (www1.nature.nps.gov/im/units/pacn).

Geographic Setting

HAVO is approximately 332,800 acres on the Island and State of Hawai`I (see map below). Hawaii is a high island in the Pacific Ocean which lies 2,500 miles southwest of California. The park is located on the summit and south slope of Kilauea volcano between the East and Southwest Rift Zones. On Mauna Loa volcano the park includes the summit, Southwest Rift Zone, and a strip between the two summits of Mauna Loa and Kilauea. HAVO consists of two major units: 217,000 acres centered on Kilauea and the land between the summits of Mauna Loa and Kilauea. HAVO also includes a newly acquired 115,800 acre addition called Kahuku on the Southwest Rift Zone of Mauna Loa between the summit and 2,500 feet elevation. All park lands are located above the mean high tide zone. With its drive-through volcano and accessible lava flows, the park is the single most visited tourist destination in the state. However, there is minimal development within the park and only light pressure from outside sources to significantly expand visitor facilities. “The Park is bounded by extensive tracts of state and private lands, providing opportunities for conservation and recreational partnerships, particularly in montane areas. The largest adjacent parcels include state lands in conservation dedicated Natural Area Reserves, multiple use state forest reserves, state lands leased for cattle ranching, and private lands used for a mix of uses including logging, ranching, and conservation. The community of Volcano is located just outside the Park near the summit of Kilauea. This is a low density rural/residential community of approximately 2,500 individuals. A community based planning effort, Vision 2020, seeks to carefully plan development and encourage retention of the native forests in which the community is located.” (1999, HAVO RMP Draft) Much of the upland areas of the park are in conservation partnerships or have the potential for such partnerships. Conservation partnerships are essential to combat the invasion on adjoining rural lands by invasive species.



Significant Natural and Cultural Resources

The natural resources the park was set to protect are the geological processes and volcanic activity. After park establishment, the significant biological resources became recognized. The most significant resources for protection are: the plants, birds and invertebrates of its diverse mesic forests (the most species rich habitats in the park) ; plants and invertebrates of the rain forest (the single largest tract of tropical rain forest under federal protection); lava flow and kipuka successional mosaics; upper montane, subalpine, alpine, and aeolian ecosystems on Mauna Loa; relict lowland dry forest and coastal strand; cave ecosystems; rare species including 25 T&E plants and seven endangered vertebrates; relictual native bird fauna; cultural significant vegetation and plant communities harvested for traditional uses; anchialine pools and scattered wetlands; and remnant patches of native habitat left in degraded ecosystems that are targeted for restoration.

Kilauea, the home of Pele, is sacred to many Native Hawaiians. The Park preserves the remnants of native ecosystems and cultural and sacred sites that are necessary for the perpetuation of the traditional values of Native Hawaiian culture. Hawaiians are

permitted free access to the Park for religious purposes and, under a permit system, to practice traditional collecting of selected plant materials. (1999, HAVO RMP Draft)

Resource Management Priorities

The following goals from the Resource Management Plan express park management priorities for natural resource management: 1) Restore Park ecosystems recently invaded by alien species through removal of key alien species followed by natural recovery; 2) Restore highly altered Park ecosystems through a program of active rehabilitation to feasible natural conditions; 3) Restore lost biodiversity in Park ecosystems by recovering endangered, threatened and rare plant and animal species, and by reintroducing locally extirpated species; 4) Develop and maintain an understanding of populations, communities, ecosystems, threats, stressors, and ecosystem health through a systematic, science-based program of inventory and monitoring; 5) Maintain and expand Park partnerships for natural resource management, particularly those involving neighboring lands and control of invasive species threatening parklands; 6) Reduce the negative impacts of wildfire but use fire as a restoration tool when possible; and 7) Monitor air quality and composition to protect employee health and understand ecosystem change.

NATURAL RESOURCES

Focal Ecosystems and Processes

Hawaii Volcanoes National Park is best known for its geological processes and volcanic activity but it also has a wide variety of biologically unique and significant resources.

Focal Ecosystems

- Rainforest
- Mesic Forest
- Early successional lava flows and lava flow/kipuka mosaics
- Upper montane, subalpine, alpine and aeolian ecosystems on Mauna Loa
- Relict lowland dry forest and coastal strand
- Cave ecosystems

Threatened and Endangered Species

- 25 threatened and endangered plant species, 5 candidates for T & E status, 22 species of concern, and 40 rare plant species
- Hawaiian Hoary Bat, Hawaiian Hawk, Nene, Dark-rumped petrel, Akepa, Hawaiian Creeper and the Hawksbill turtle

Processes

- World Heritage Site

Approximately 33,000 acres of rain forest are found in the HAVO Ola`a forest, the summit area of Kilauea, Kilauea's East Rift Zone, and Kahuku at approximately 3,500 foot elevation, and adjacent to the park in the Kau Forest Reserve. Species richness is greatest in the Park in two small stands of diverse mesic forest at around 4,000 foot elevation. However rain forests, because of their extensive nature and relatively high number of species, contain much of the Park's biological diversity. HAVO's Ola`a rain forest is home to rare and endangered species of plants such as *Sicyos alba*, *Cyanea tritomantha*, *Cyrtandra giffardii*, and *Pritchardia beccariana*.

Mesic forest on the slopes of Mauna Loa contain rare and endangered species of vertebrates, plants and invertebrates such as Hawaiian Hoary Bat, Hau Kuahiwi (*Hibiscadelphus giffardianus*), Alani (*Melicope zahlbruckneri*), and several picture wing *Drosophila spp*. Kipuka Ki and Kipuka Puaulu are two mesic forest communities, have been designated as Special Ecological Areas (SEA's) where there is intensive management for removal of alien plants and restoration with native plant species. Early successional lava flows and kipuka mosaics are examples of evolutionary processes which are a unique resource at Hawaii Volcanoes National Park.

World Heritage site designation is partly based on the presence of Mauna Loa and Kilauea volcanoes at Hawaii Volcanoes National Park. Intensive scientific study of the volcanoes is underway by the Hawaii Volcano Observatory and University of Hawaii collaborators. Due to protected and significant native ecosystem managed by the National Park Service, this provides a protected environment for research and education.

Threats & Stressors

Alien species

- Invasive plant species
- Small mammals
- Avian diseases
- Introduced birds and invertebrates
- Introduced ungulates

Fire

- Wildfires caused either by humans, lava flows or lightening

Geologic Hazards

- Lava flows

Adjacent Landowners

- Grazing on neighboring ranches
- Lack of management on adjacent natural areas and build up of invasive species

Visitors

- Introduction of weed species
- Release of unwanted pets
- Visitor use ecological impacts

The most significant threats to natural resources in HAVO are alien species. Over three decades, feral ungulates including pigs and goats have caused extensive damage to native ecosystems in Hawaii Volcanoes National Park. Control efforts have been highly successful, for example goat populations are near zero in the park. Feral pigs have been controlled in much of the wet and mesic habitats in the park. However, Mouflon sheep are widely distributed in the new Kahuku section of the park and they are voracious browsers with the ability to deplete rare plant species even at low densities.

Introduced small mammals, particularly rats, mongooses, and feral cats are one of the most significant causes to the loss of biodiversity in Hawaiian ecosystems. These species inhibit the recovery of many native Hawaiian species. All three rat species, the black rat,

Norway rat, and Polynesian rats, as well as introduced house mice are present in the park. Predation on eggs, nestlings, and young birds is widely postulated as one of the leading causes of the decline of Hawaiian bird species and a critical limiting factor for rare species. Mongooses have been documented as predators on Nene eggs, Nene goslings, and sea turtle nests. Healthy mongoose populations may be an important reason for failure of the native Nene to become re-established in some wild land areas. Predation by feral cats has been documented on many ground and tree nesting species of Hawaiian birds, in HAVO, they are significant predators of Nene, Dark-rumped, and Band-rumped Storm Petrel. In fact feral cats may be the single most important limiting factor for petrels in their relictual alpine habitat.

Avian disease carried by mosquitoes has a major impact on the native bird populations in HAVO. In addition, introduced birds such as Kalij pheasants and Japanese white eye could be competing with native birds for food resources and spreading weed seeds. Alien species of invertebrates such as yellow-jacket wasps could be competing with native insects for resources, and are voracious predators of native invertebrates. Introduction of new alien species of plants, vertebrates, and invertebrates such as the Brown Tree Snake, West Nile Virus, or Miconia and others may likely be detrimental to the avian populations in Hawaii Volcanoes National Park.

The dry Ohia dominated woodland in Hawaii Volcanoes National Park has been invaded and colonized by many nonnative plants, including fire-promoting tropical and subtropical grasses. Fire frequency has increased 3-fold and fire size over 60-fold since the 1960's and early 1970's. Park fire and resource management programs now emphasize rehabilitation by establishing fire tolerant native trees and shrubs. These species can persist or spread in dry woodlands and coastal lowlands where fire has been most widespread and has had the greatest impact on native ecosystems.

Another threat is lava flows which have covered irreplaceable lowland forest and created fires which have destroyed unique forest types in the park. Fires caused by humans have also destroyed and changed plant communities.

The potential encroachment of boundary areas and incompatible uses such as cattle grazing in Kapapala Ranch, could have a negative impact on the landscape and biota of HAVO. The lack of management of surrounding natural areas, such as no alien species management in Tract 22 and in Kahaualea Natural Area Reserve could cause ingress of alien species from these areas into the park.

Visitors may also impact the natural resources within HAVO such as removal of plants, introduction of new weed species via unclean gear and footwear, and release of unwanted pets such as rabbits.

Water Quality Designations

In Hawaii, water bodies are classified by their designated use according to the Hawaii Revised Statutes, Section 11, Chapter 54 which contains definitions and water quality

standards for each water body type with respect to desired uses. Waters which do not meet the criteria for their designated uses are considered non-supportive and, if certain conditions are met, may be reported as impaired to the Environmental Protection Agency as per requirements of the Clean Water Act, Section 303(d). HAVO's unique or pristine water resources include anchialine pools, Olaa bogs and coastal waters. These inland surface waters are classified as 1a; prohibiting pollution by humans and requiring maintenance of their natural wilderness character. This same protection is extended to marine waters classed as AA and marine bottom ecosystems category II. Groundwater designations are being developed by the state of Hawaii, but are not available at this time. The Hawaii State Department of Health's water quality standards are available at <http://www.hawaii.gov/doh/rules/11-54.pdf>.

CULTURAL ISSUES

- Sacred sites
- Lava tubes or caves

“Hawaii Volcanoes National Park preserves the remnants of native ecosystems, and cultural and sacred sites that are necessary for the perpetuation of the traditional values of Native Hawaiian culture. Continual consultation with the native Hawaiian community, both formal and informal, is needed to ensure that traditional Hawaiian customs and values are respected while carrying out NPS resource management and protection responsibilities and maintaining a quality Park experience for visitors.” (2000, HAVO Strategic Plan). Hawaiians are permitted free access to the Park for religious purposes and, under a permit system, to practice traditional collecting of selected plant materials.

HAVO contains many miles of underground lava tubes or caves which were utilized by Hawaiians for refuge, water collecting, burials, and other uses. Some lava tubes contain significant archeological resources, while others may contain Ohia (*Metrosiderous polymorpha*) or other plant roots contain endemic, cave adapted insects, and microorganisms. Many caves contain special geologically significant features and mineral deposits. Currently most Park caves are closed to public use because their resource values are not known. Once the status of resources is known and safety hazards are assessed, caves may be classified in terms of use by researchers or the public. Resources in about 10 caves have been inventoried.

MANAGEMENT ISSUES

Park management documents (General Management Plan, Resource Management Plan, etc.) are available on-line at the NPS intranet site (www1.nrintra.nps.gov/im/units/pacn/parks/mgmt_docs.htm). This website is available only from NPS computer networks. Inquiries about public access should be directed to the park. Management documents for HAVO can be found at the Hawaii Volcanoes National Park library.

Park Management

Invasive Species

- Identification and control of incipient alien species inside the park as well as those species external to the park that are threatening to invade and alter park ecosystems
- Control of established invasive species in the park
- Development of tools to control alien invertebrates such as wasps. Likewise, alien control measures for vertebrates such as small mammals, and mouflon sheep

Loss of Biodiversity

- Stabilization of selected T&E species, Species of Special Concern, and full recovery of flagship species.
- Restoration of biodiversity in recovering or restored park ecosystems through species reintroduction or other restoration programs.
- Control of disturbance sources including feral ungulates, as well as fire and key alien plant species to allow natural recovery of native ecosystems, particularly in relatively intact, priority areas of the park.
- Maintenance of soundscapes, lightscapes, and wilderness qualities including ecological integrity and biodiversity.

Management Needs

- Increase staffing needs for alien species control, restoration, and monitoring programs.

At Hawaii Volcanoes National Park there are approximately 600 naturalized alien plant species. The native vascular plant flora consists of approximately 400 species. Non-native vertebrates consist of feral goats, feral pigs, mouflon sheep, mongooses, three species of rats, feral cats, 22 alien bird species, and numerous alien invertebrate species including predatory yellow-jacket wasps and several species of ants. Hawaii Volcanoes National Park goals include restoration of Park ecosystems recently invaded by alien species through removal of key alien species followed by natural recovery. Secondly, HAVO goal is to restore highly altered Park ecosystems through a rehabilitation program to natural feasible conditions. The Park will also expand restoration efforts focused on localized model areas to a park-wide scale.

HAVO has 25 endangered or threatened plant species, accounting for approximately seven percent of the Park's vascular plant flora. There are also 24 Species of Concern; an additional 55 plant species are rare in the Park. Five of the Park's resident vertebrate species are endangered or threatened: Nēnē, Dark-rumped Petrels, Hawksbill Sea Turtle, Hawaiian Hoary Bat, and Hawaiian Hawk. There are also many rare invertebrate species in the Park, as indicated by the presence of 42 Species of Concern or former candidates in HAVO.

To better manage natural resources at Hawaii Volcanoes National Park there is a need for more information on the health and trends of ecosystems found within the park. Landscapes and ecosystems change rapidly in the park with volcanic activity, alien species invasions and the highly manipulative management needed to restore native ecosystems. Most park alien species control is done in a adaptive management mode in which management strategies are altered by monitoring information. One goal of the park is to develop and maintain an understanding of populations, communities, ecosystems, threats, stressors, and ecosystem health through a systematic, science-based program of inventory and Park Management.

INVENTORIES

Existing Inventories in Park

Vegetation: Vascular plants of HAVO have been well documented starting with the field work and voucher collection by Fagerlund and Mitchell 1944. In 1947 Fagerlund added a list of alien plants found in HAVO, and Stone (1959) added species from the Kalapana extension. Doty and Mueller-Dombois produced generalized vegetation maps of the Park in 1966 and Fosberg produced a checklist of vascular plants of HAVO by updating Fagerlund and Mitchell's checklist with newer collection information. This checklist was again updated by Fosberg and published as a CPSU Technical Report in 1975. Herat and Herat (1975) compiled an updated list of ferns and fern allies based on field surveys and herbarium specimens of earlier collectors in the Park. Higashino et al. (1988) compiled a checklist of vascular plants of HAVO from the preceding works and from newer field studies and surveys. This checklist was revised by Linda Pratt (one of the original co-authors) in 1998 and is the main source used by the NPSpecies database for HAVO vascular plants.

A brief ecological survey of lichens in Hawaii Volcanoes National Park was conducted in 1999. A total of 304 voucher specimens were collected representing 84 taxa and 43 genera. All vouchers are in the Hawaii Volcanoes National Park Herbarium.

A field inventory has been completed of vascular plants of the remote volcanic trench in the Ola`a rainforest. The unpublished report of this inventory is forthcoming.

Distribution and abundance maps of threatening alien plant species on adjacent lands proximal to HAVO are also being inventoried. The field surveys for a map of selected incipient alien plant threats on proximal lands to Hawaii Volcanoes National Park is completed and the report is forthcoming.

To develop a more complete checklist of moss species occurring at HAVO, surveys are being conducted of less visited areas of the park. Moss specimens will be stored in the HAVO Herbarium as permanent record of the presence of such species in the park.

Terrestrial Vertebrates: The first extensive bird inventories were done by two student technicians of the CCC in 1937 (Donaghho 1937, Craddock 1937). A park checklist was

made by Baldwin in 1941 based on more thorough surveys conducted in 1938 and 1939 and on historical records of extinct birds. In 1948-1949 Baldwin (1953) conducted several surveys in 2 week intervals at forest sites from 610-2135 m (2000 to 7000 ft) elevation as part of a study to track annual, elevational movement of native forest birds. Dunmire (1962) conducted surveys in 1959-1961 paralleling Baldwin's forest bird surveys representing a change of # spp and found 23 species. Berger (1972) and Conant (1975) surveyed bird species distribution patterns in the park as well as adjacent Kilauea Forest Reserve and Keauhou Ranch during the U.S. International Biological Program. Scott et al. (1986) and Conant (1980) conducted surveys in 1979-1980 and found 29 and 26 bird species respectively.

An inventory of seabirds was conducted in 2001 using marine radar to identify seabird flight corridors within Hawaii Volcanoes National Park. Due to inaccessibility of coastal areas within HAVO only one station, Holei sea arch, at the end of Chain of Craters road was surveyed and found no evidence of Dark-rumped Petrel, Newell's Shearwater, and Band-rumped Storm Petrel colonies. Reasons attributed to the lack of results could be, time of the year, the amount of nights surveyed, or the location of the survey station. The intent of this inventory was to provide information to assist in ground searches for the Seabird Colony Focused Searches Project to be later funded by the Inventory and Monitoring Program.

Terrestrial Invertebrates: HAVO has the largest invertebrate specimen base than any other park in the PACN network. This is due to an intensive inventory of terrestrial invertebrates from 1971 to 1976 through the US International Biological Program Island Ecosystems Integrated Research Program. A field research station has also supported additional smaller invertebrate surveys. In addition the park maintains an invertebrate specimen collection initiated in the 1940s as part of its natural history museum. However, only a small fraction of its more than 332,800 acres have been surveyed for terrestrial invertebrates.

Freshwater/Anchialine Communities: An inventory of 19 anchialine pools was conducted in 1989 by Chai and colleagues, although other pools are known to exist. One of the pool complexes (Waha'ula Wet Cave) has since been covered by lava. As part of the anchialine pool invertebrate inventory being conducted by D. Foote in 2003-2004, several anchialine pool complexes are scheduled to be surveyed. Accurate identification and mapping of these pools is another important component of these inventories. Since 2003, D. Foote has been monitoring pool-breeding damselflies and flies, as well as habitat, in the 'Ola'a Pua unit.

Marine Communities: The fish fauna of HAVO is very limited because the park's boundary ends at the high tide mark and with no freshwater streams. The only fish habitats in the park are brackish water anchialine pools along the coast. Chai 's 1989 inventory found 7 fish species and 7 identifiable invertebrates in 19 anchialine pools. All the species were native except for an alien invasive species of prawn known to limit the populations of native shrimp species.

Marine fish species were surveyed twice in waters just offshore of HAVO. Major (1976) produced an unpublished list of 54 fish species seen from reefs surveyed near the coastal backcountry campsite Halape. Ball (1976) recorded 25 (including 14 not recorded by Major) fish species, 106 invertebrate species, and 89 species of algae in the tide pools near the Halape campsite.

Geology: Field work for the island of Hawaii soil survey was completed in 1957. The classification and map unit names were finalized in 1968, and the Island of Hawaii Soil Survey was published in 1973 at 1:24,000 scale. An evaluation was made of the soil survey in 1993, with the determination that soil map unit delineations were accurate. However, one additional map unit was added to the soil survey to reflect present day soil survey concepts, soil classification, and soil interpretations. Amendments to the correlation document reflecting these changes are on file at the NRCS Hawaii State Office.

Water Quality: A baseline water quality data inventory and analysis was conducted at Hawaii Volcanoes National Park this resulted in surface-water-quality data from six of the United States Environmental Protection Agency's (EPA) national databases: (1) Storage and Retrieval (STORET) water quality database management system; (2) River Reach File (RF3)†; (3) Industrial Facilities Discharge (IFD); (4) Drinking Water Supplies (DRINKS); (5) Water Gages (GAGES); and (6) Water Impoundments (DAMS). The report from this inventory provides; (1) a complete inventory of all retrieved water quality parameter data, water quality stations, and entities responsible for the data collection; (2) descriptive statistics and appropriate graphical plots of water quality data characterizing period of record, annual, and seasonal central tendencies and trends; (3) a comparison of the park's water quality data to relevant EPA and WRD water quality screening criteria; and (4) an Inventory Data Evaluation and Analysis (IDEA) to determine that Service-wide Inventory and Monitoring Program "Level I" water quality parameters have been measured within the study area. The primary goal of this project is to provide descriptive water quality information in a manner and format that is both consistent with the goals of the Service-wide Inventory and Monitoring Program and useable by park resource managers.

Viewsheds: From May through June 2002 historic scenic viewsheds at various locations in HAVO were inventoried using a GPS and photography. Due to the natural processes of forest succession affecting the character of historic views, these historic views need to be managed to preserve visual access to historic scenic viewsheds. In addition, an inventory to characterize different acoustic environments at HAVO was conducted to provide baseline data for the development of the upcoming Air Tour Management Plan. As part of the acoustic survey, long term continuous 1/3 octave band sound levels, wind speed, and wind direction were collected at twenty two sites at HAVO.

Priorities for New Inventories in Park

Vegetation: An integrated inventory of vascular plants, birds, and rare Invertebrates in Kahuku is in the early planning stages. The projects purpose is to understand the

occurrence and distribution of vascular plants, birds, aquatic, semi-aquatic, and rare invertebrates for the large and poorly inventoried new park annex, with an emphasis on species-rich or specialized habitats. Some examples include; the ecotones between closed forest and sublapine, pit craters and lava tube openings; forest on older substrates; and wetlands. Objectives for this inventory are to determine occurrence and/or distribution of vascular plants, rare invertebrates, forest birds, sea birds, and T & E species such as nene in known species-rich or specialized habitats, and to determine spatial relationships of these distribution patterns.

Terrestrial Vertebrates: Shoreline areas for HAVO will be inventoried for seasonal waterfowl and shorebirds migrants along designated routes. Seabirds, raptors, and native waterbirds will also be recorded. The objective of this project is to inventory avian species diversity and relative abundance along the park's shoreline. This inventory will also be conducted in other Hawaii parks such as Haleakala National Park, Kalaupapa National Historical Park, Puuhonua O Honaunau National Historical Park, and Puukohola Heiau National Historical Site in shoreline and wetland areas.

Basic herpetological surveys are needed for all of Hawaii's parks. Distributional knowledge is especially needed for a host of reptile and amphibian taxa that are invasive in native Hawaiian ecosystems and threaten to disrupt normal functions or reduce populations of native species. Because the threats posed by these species are subtle, their ecologies and their effects on native Hawaiian biodiversity have not been investigated. However, potential effects are easily deduced from knowledge gained in the native ranges of these taxa. For example, there is a critical need to ascertain the status of these alien taxa on NPS properties in Hawaii due to the invasive nature and rapid spread of some of these species in the Hawaii. Inventories will also provide information necessary to establish long term monitoring.

An inventory of the Hawaiian Hoary Bat is to be conducted across a broad array of habitats in six of Hawaii National Parks. The study will also evaluate bat habitat usage and relative abundance.

Terrestrial Invertebrates: Biological inventories of terrestrial invertebrate species of concern (SOC) are in the planning stages in HAVO. The objectives of these inventories are to; 1) Compile specimen-level data for *Drosophila* and *Megalagrion* terrestrial SOCs, and use collection locality data in conjunction with vegetation and rainfall maps to delineate potential habitat for each species, (2) Survey these species along existing HAVO Resource Management transects, (3) Conduct focal searches in other likely habitat (i.e. microtopographic features such as Olaa Trench), and (4) Estimate search effort required to expand scope of inventory to include other rare or missing endemic species of *Megalagrion* and *Drosophila*.

MONITORING

Existing Monitoring in Park

Vegetation: Both previous and existing vegetation monitoring projects at Hawaii Volcanoes National Park include:

- Vegetation recovery and restoration efforts of native plants within burned areas such as the Kupukupu , Panau Iki, and Broomsedge fires;
- Alien plant removal, monitoring and mapping of weeds, *Morella faya*, *Rubus ellipticus*, *Rubus argutus*, *Passiflora tripartita* and *Hedychium gardnerianum* mainly in Special Ecological Areas (SEA's);
- Rare and endangered plant species monitoring in SEA's concentrating mainly on species targeted for recovery which include species on Mauna Loa (*Silene hawaiiensis*, *Plantago spp*), rare plants in Ola`a rainforest, Naulu forest ,and in lowlands;
- Restoration, stabilization and outplanting efforts in coastal strands, Ohia lowland communities, lower Mauna Loa, Kipuka Ki and Kipuka Puauulu;
- Effects of goat and pig removal on vegetation

Terrestrial Vertebrates: Two dominant vertebrate monitoring projects on going at HAVO are the Nene monitoring project which began in the early 1970's, and Dark-Rumped Petrel monitoring on Mauna Loa which began in the mid 1990's. Removal of feral ungulates (i.e, pigs and goats) was successfully completed during the 1970's through the 1990's. Monitoring for ingress of animals into fenced units within the park is carried out regularly to keep feral ungulate populations at zero within the park.

Forest bird surveys in HAVO provided critical information on bird distribution and densities along moisture and elevational gradients. HAVO is uniquely situated along a moisture gradient (<1000 - > 4000 cm annual rainfall) ranging from wet to mesic to dry forests. Monitoring bird populations along this gradient provided insight into ecological dynamics and population responses not available elsewhere. The park provided the only recent source of forest bird data along an elevational gradient (2000 – 7000 ft.; East Rift Zone to Mauna Loa Strip transects). However, this monitoring ceased in the mid 1990's. A long term monitoring program is essential to determining population fluctuations and changes, and species' range contractions/expansion.

Terrestrial Invertebrates:

- Yellow jacket wasp populations are being monitored to understand timing and efficacy of insecticidal baits to control populations at HAVO. Withdrawal of the two most common wasp pesticides from the market led to additional bait and toxin testing. This testing is associated with more intensive localized monitoring to measure efficacy of alternative insecticides under registration consideration.
- Monitoring of two-spotted leafhopper populations was implemented in 2001. This monitoring was initiated following the discovery of its association with the native

ohia decline and alien faya tree expansion centered in seasonal submontane habitats. Monitoring is ongoing and provides data on trends in leafhopper populations throughout the park.

- Mosquito monitoring is being conducted in conjunction with a National Science Foundation Biocomplexity Project to understand vector relationships to avian disease and the decline of native forest birds.

Other invertebrate monitoring projects have been conducted at HAVO including *Megalagrion* distribution, abundance, and potential breeding site surveys. In addition, moths species variation during different times of the year is being investigated along with population numbers and community composition of *Drosophila*.

Marine Communities: The annual Hawksbill turtle monitoring program (June-December) is the only marine monitoring program at HAVO, which began in 1989, to monitor nesting beaches in and outside the park. This project uses mainly volunteer help to collect field observations.

Geology: Volcanic activity monitoring is conducted by the Hawaiian Volcano Observatory, U.S. Geological Survey. Regular monitoring of eruption activity, seismic activity, ground deformation, and volcanic gases aid in the prediction of volcanic events within Hawaii Volcanoes National Park, and assist with recommendations to keep the public and visitors safe.

Air Quality: HAVO is classified as a Class I area, under the Clean Air Act, making monitoring for visibility, pollutant gases, and particulate matter mandatory. Monitoring of visibility, particulate matter, dry deposition, gaseous pollutants, wet deposition, cloud or fog water, solar radiation, meteorology, and climate is or has been conducted at Hawaii Volcanoes National Park. Monitoring stations are operated by the Environmental Protection Agency, the National Park Service, U.S. Geological Survey; Hawaiian Volcano Observatory and the Pacific Island Ecosystem Research Center, and the University of Hawaii at Manoa.

In Hawaii volcanic emissions and their accompanying ecosystem and public health effects are of special concern. HAVO's air quality is at the clean compared to that of mainland areas because of its extreme isolation. However, due to volcanic emissions, air quality conditions in HAVO exceed the standards set by state and federal agencies for anthropogenic emissions several times a year.

Visitor Use: Visitor use at Hawaii Volcanoes National Park is monitored daily, including total visitor numbers of vehicles, recreational vehicles, non-recreational vehicles, bus vehicles, campground tents, Volcano House use, Kilauea Military Camp use, and Backcountry campsite use at Halape, Kaaha, Keauhou, ML Summit cabin, Napau, Pepeiau and the Red Hill cabin. This data can be used to monitor the impact of visitors on flora and fauna of the parks backcountry resources but such monitoring is yet to be implemented.

Buffer Zone Monitoring

Vegetation: The Olaa-Kilauea partnership includes Hawaii Volcanoes National Park, the Kulani Correctional Facility, Dept of Land and Natural Resources, and Kamehameha Schools. The overall goals of the partnership include enhancing long-term survival of native plant communities and natural processes, maintaining a healthy forest ecosystem, protecting and managing large contiguous areas across ownership boundaries, and recovering rare and endangered species of plants and animals.

The Pu`u Makaala Natural Area Reserve adjacent to Hawaii Volcanoes National Park is managed by the Department of Land and Natural Resources, Division of Forestry and Wildlife. The NARS (Natural Area Reserve System) were created to preserve and protect representative samples of Hawaiian biological ecosystems and geological formations. Management teams are working to control the encroachment of non-native plants and animals which threaten the existence of the natural biota on the reserves.

CONCLUSIONS

Designated as a national park, management priorities focus on preserving natural resources. Natural resources include rocky and sandy beaches, sea cliffs, anchialine pools, lowland grassland, dry forest, rainforest, mesic forest, mid-elevation and alpine desert, lava fields, caves and lava tubes, sub-alpine shrubland, and multiple active volcanic features. Primary threats to resources include volcanic activity, invasive species, and wildfires.

Diverse partners such as Federal agencies, state or local agencies, universities, community groups, or local schools all are to assist with needed monitoring of natural and cultural resources within national parks. Partnerships provide access to technical specialties needed to complete natural resource management tasks, foster interagency understanding and discovery of common ground, promote innovation of new ideas, and strengthen support for dealing with complex issues. In summary, partnerships are critical to the success of natural resources management.

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